Soil Carbon Storage and Dynamics in a Subtropical Savanna Ecosystem

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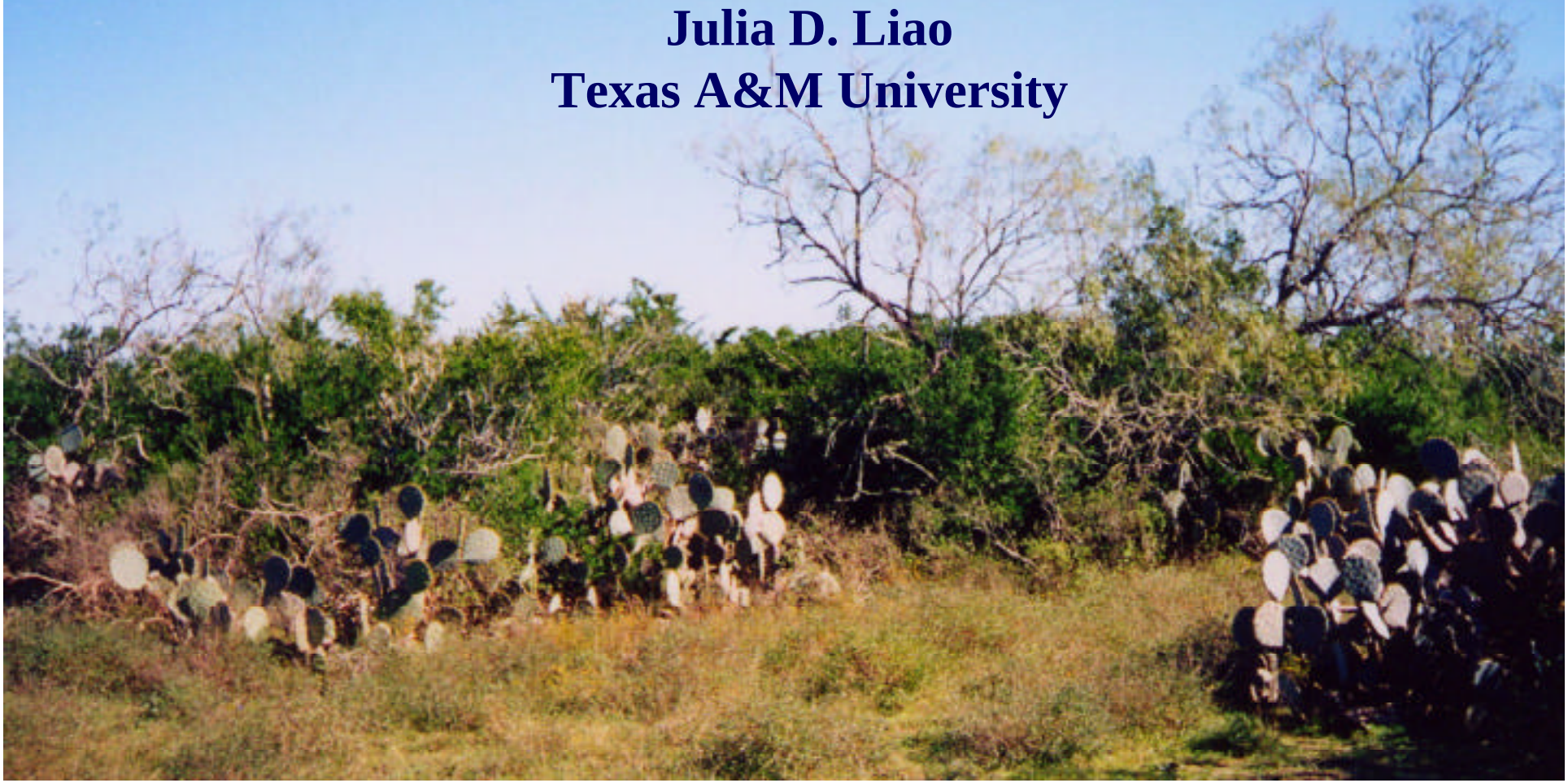
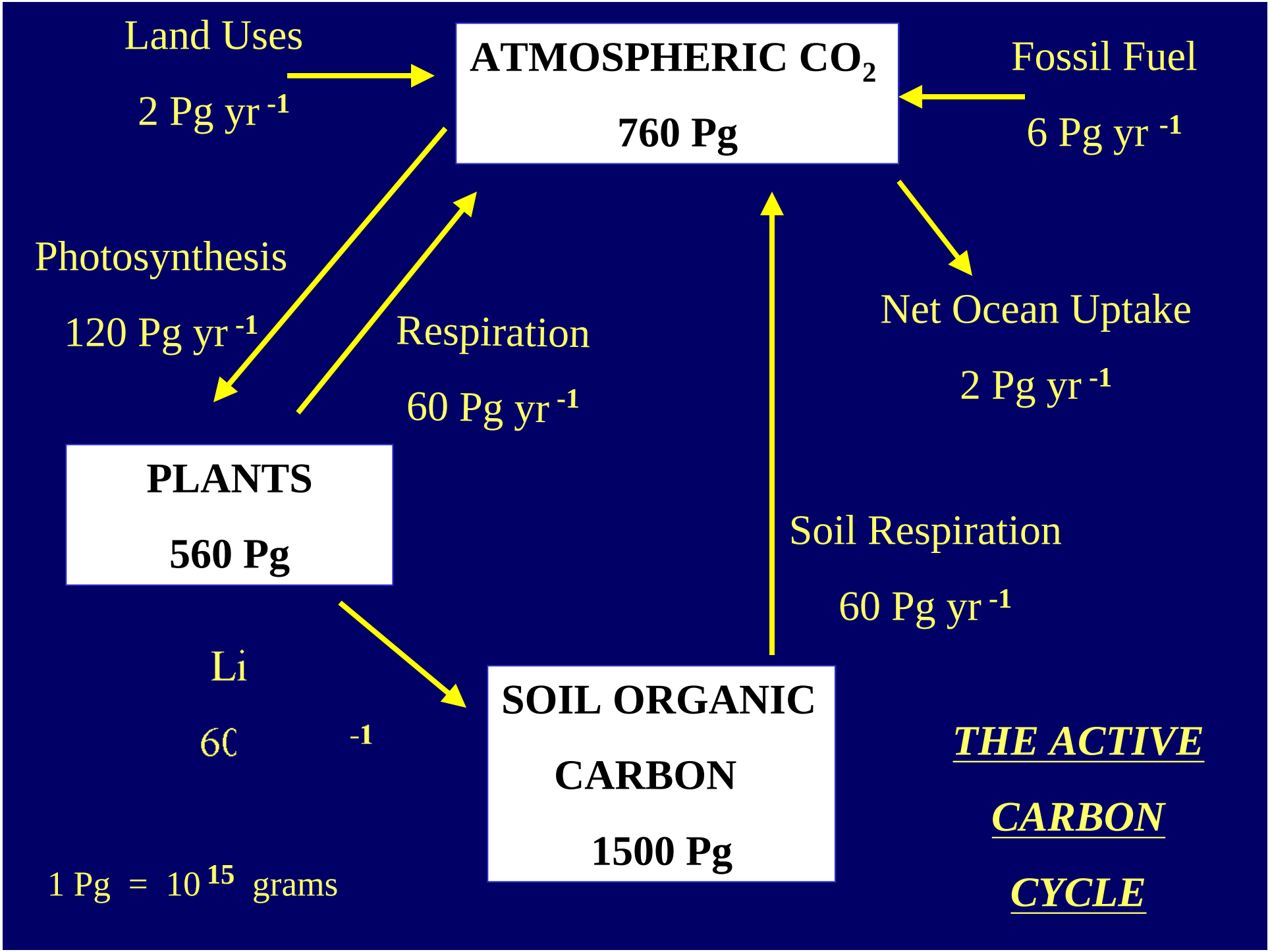
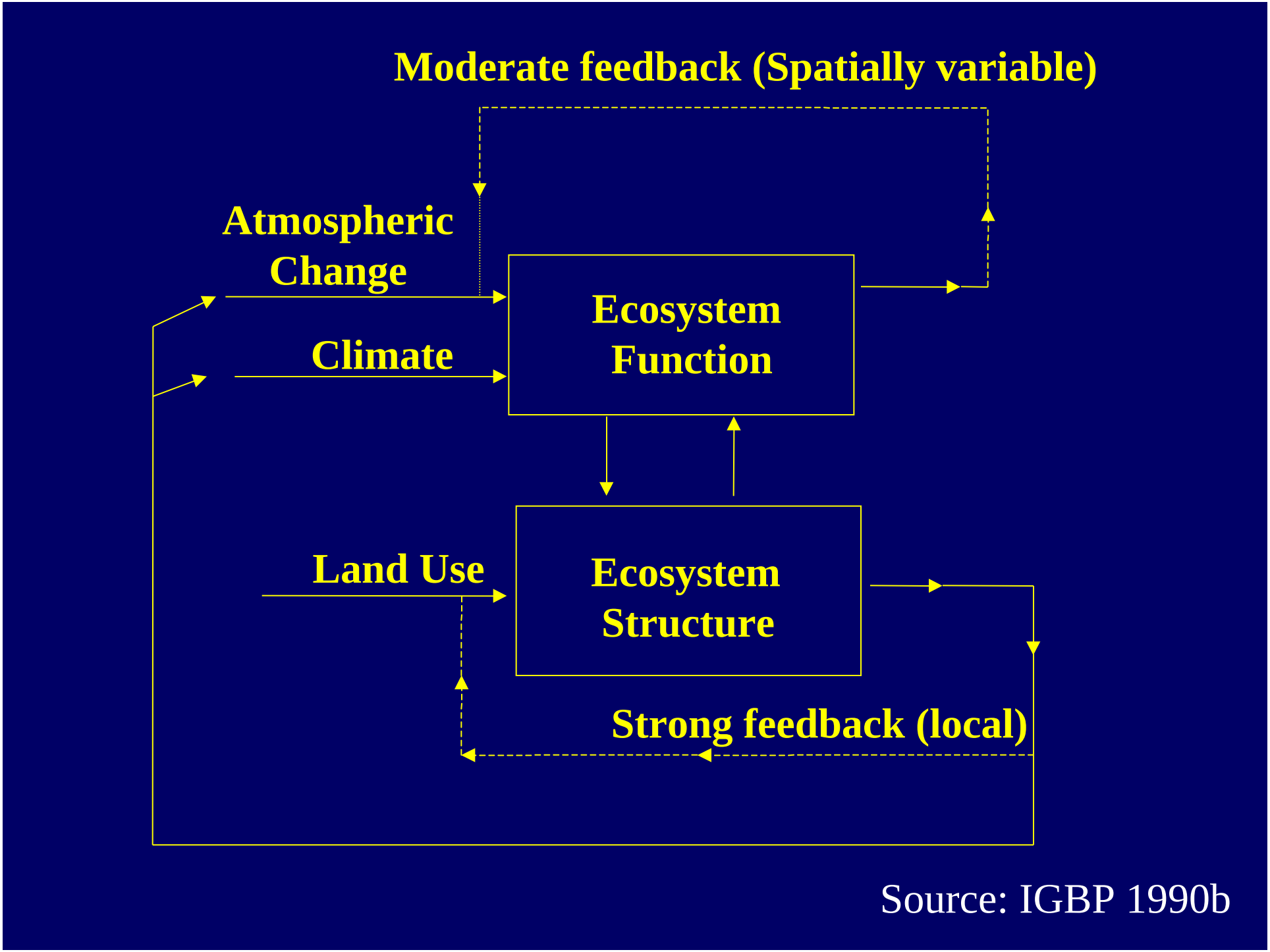
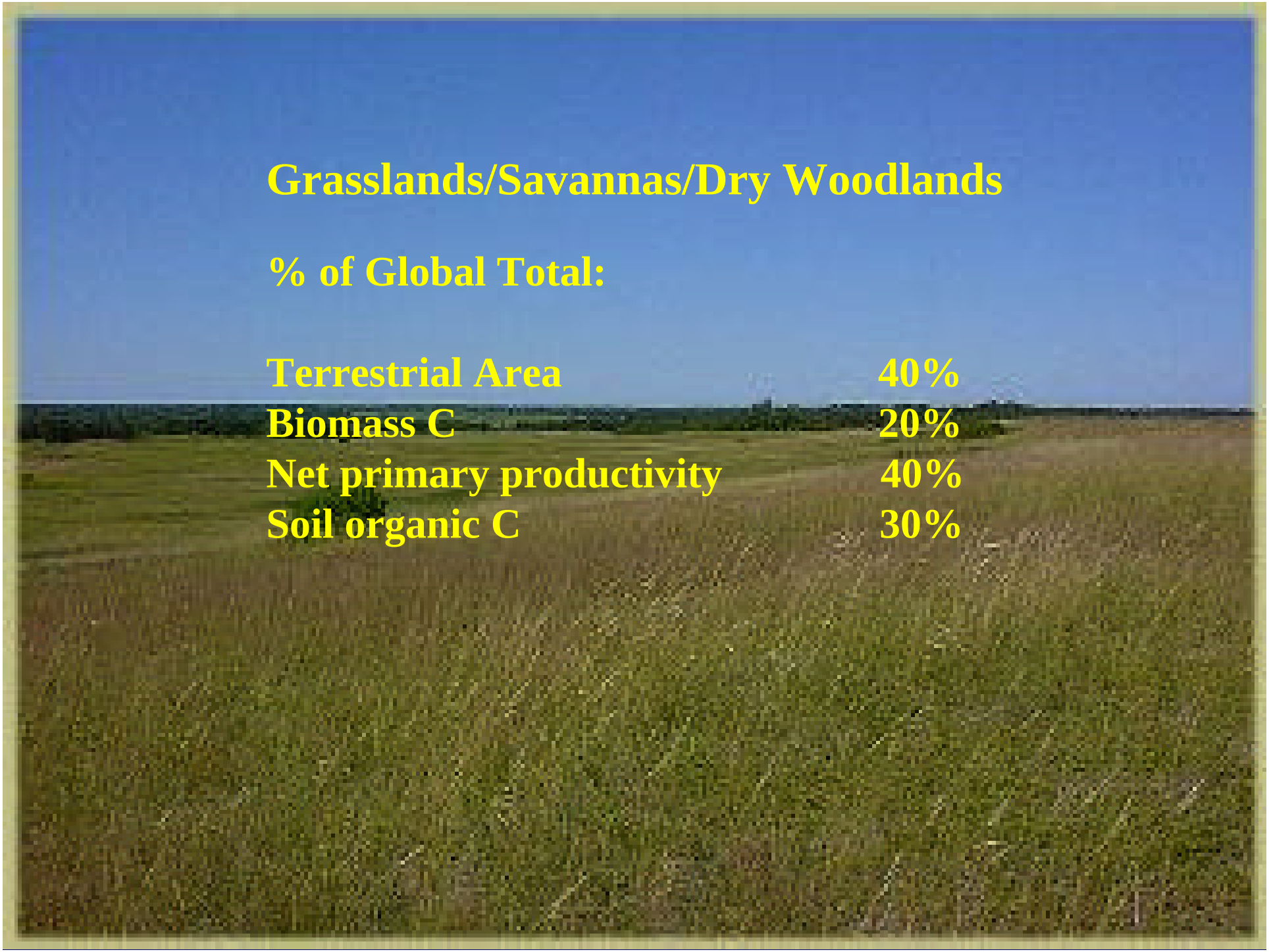



Land Uses
2 Pg yr -1
ATMOSPHERIC CO2
760 Pg
Fossil Fuel
6 Pg yr -1
Photosynthesis
120 Pg yr -1
Respiration
60 Pg yr -1
Net Ocean Uptake
2 Pg yr -1
PLANTS
560 Pg
Soil Respiration
60 Pg yr -1
Li
60 -1
SOIL ORGANIC CARBON
1500 Pg
1 Pg = 10 15 grams
THE ACTIVE CARBON CYCLE



Source: IGBP 1990b

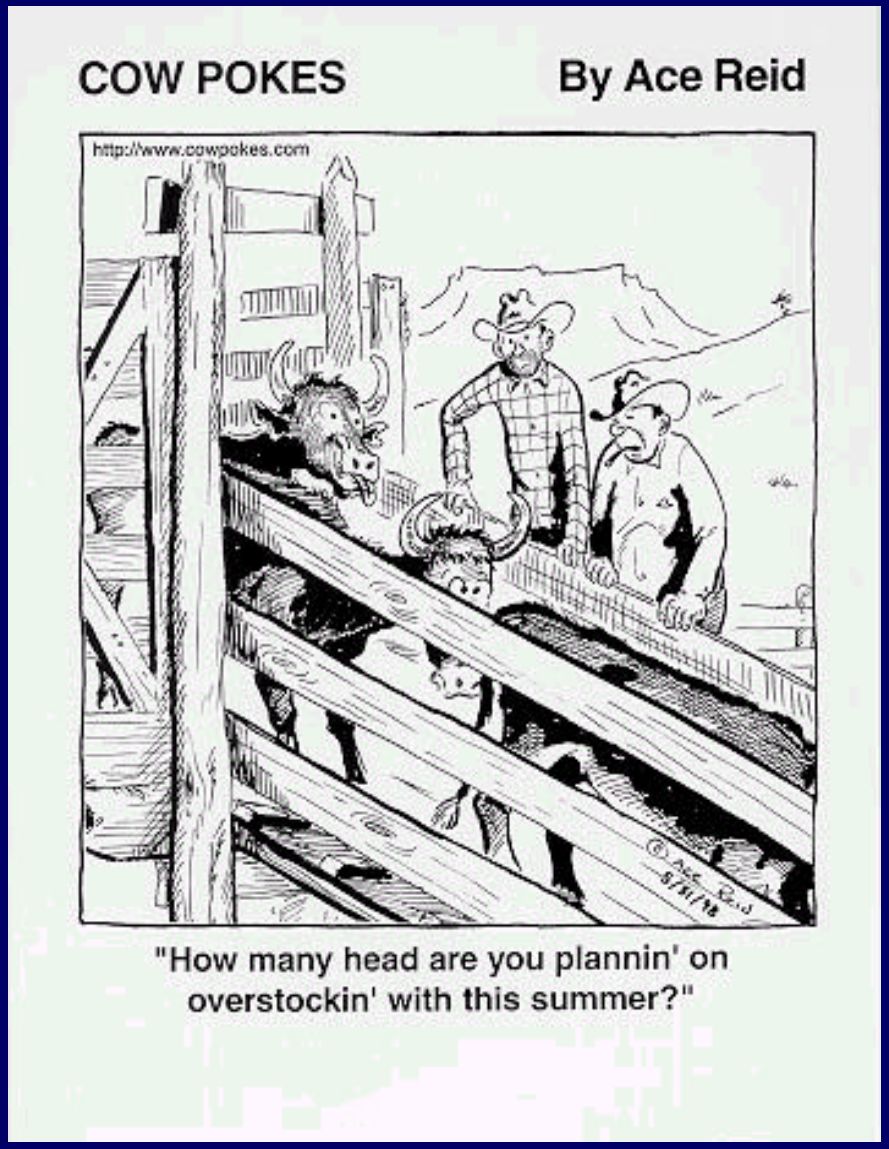


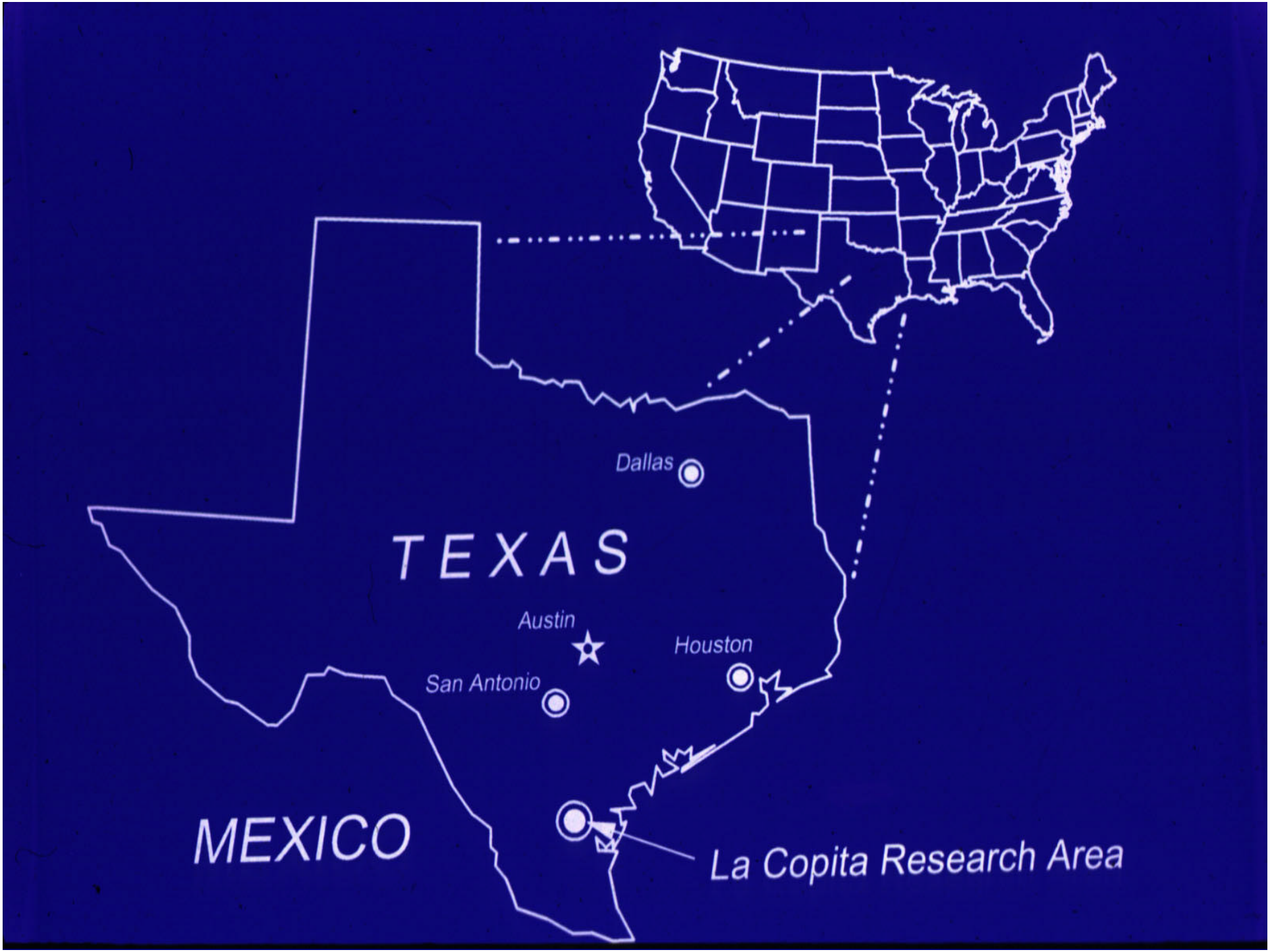
Grasslands/Savannas/Dry Woodlands

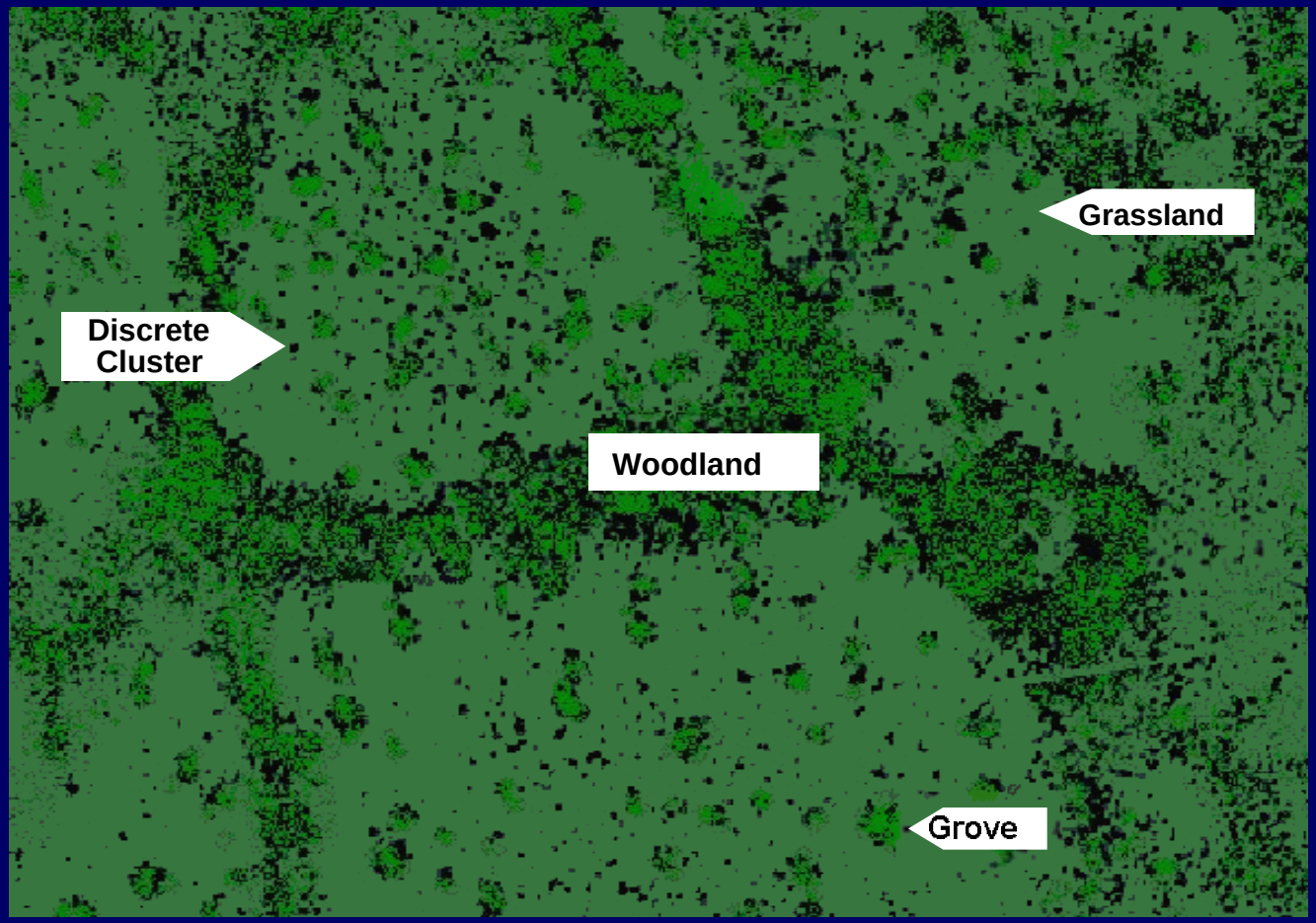
% of Global Total:

Terrestrial Area	40%
Biomass C	20%
Net primary productivity	40%
Soil organic C	30%

Fire/Grazing



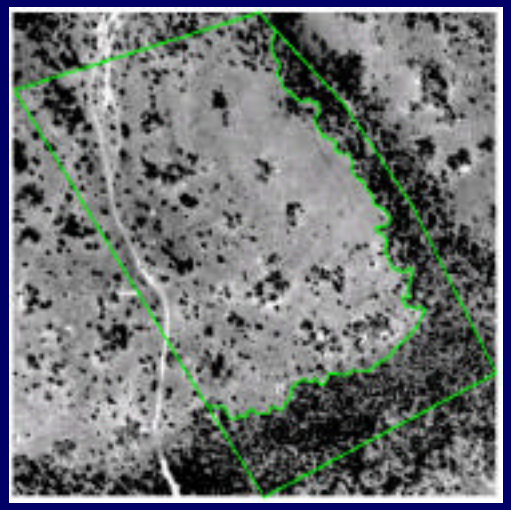

Dallas
TEXAS
Austin
Houston
San Antonio
MEXICO
La Copita Research Area



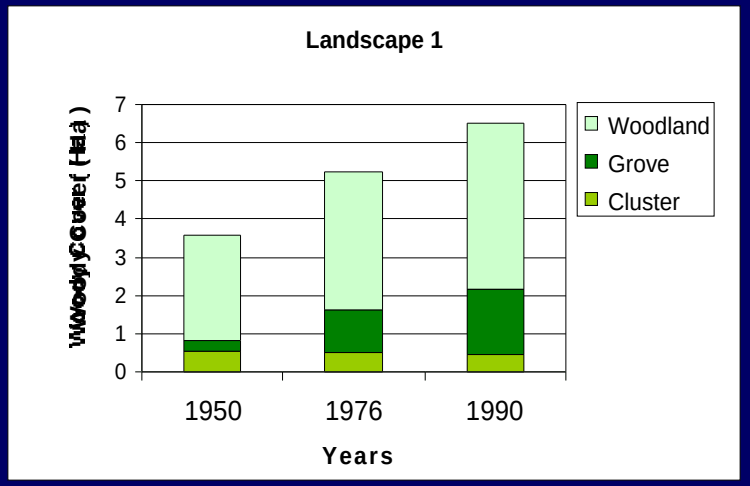
Aerial view of the study area in southern Texas. Lighter areas are upland **remnant grasslands**. Dark areas within the upland grasslands are **clusters** (smaller spots) or **groves** (larger spots) dominated by woody plants. Continuously dark areas surrounding the uplands are low-lying **drainage woodlands**.

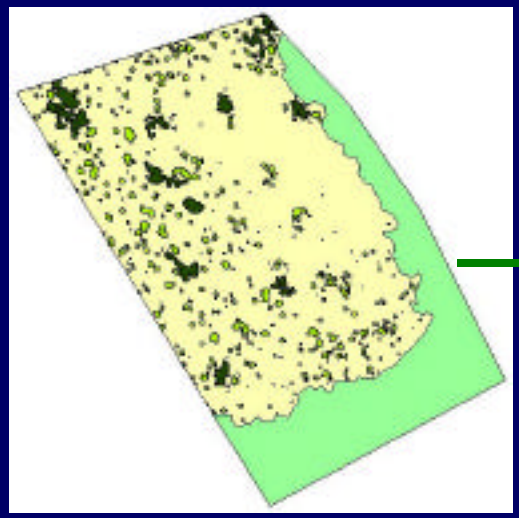
Changes in Woody Plant Cover, 1950-1990:

Landscape 1: 1950



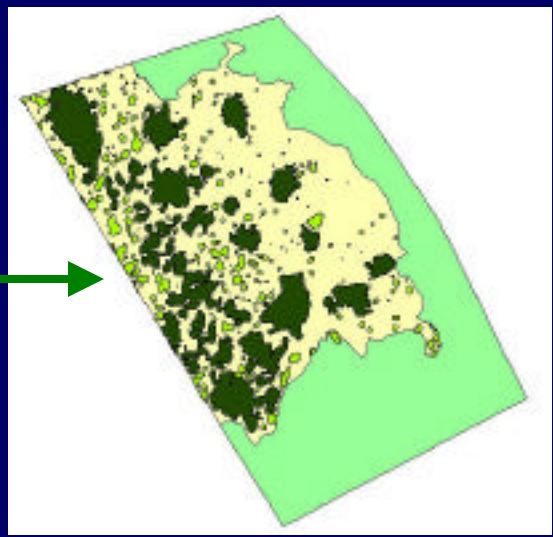
- Woodlands
- Groves
- Clusters
- Herbaceous





1950

1976



1990

OBJECTIVE

To quantify changes in soil C storage and dynamics resulting from grassland-to-woodland succession in the Rio Grande Plains of southern Texas by:

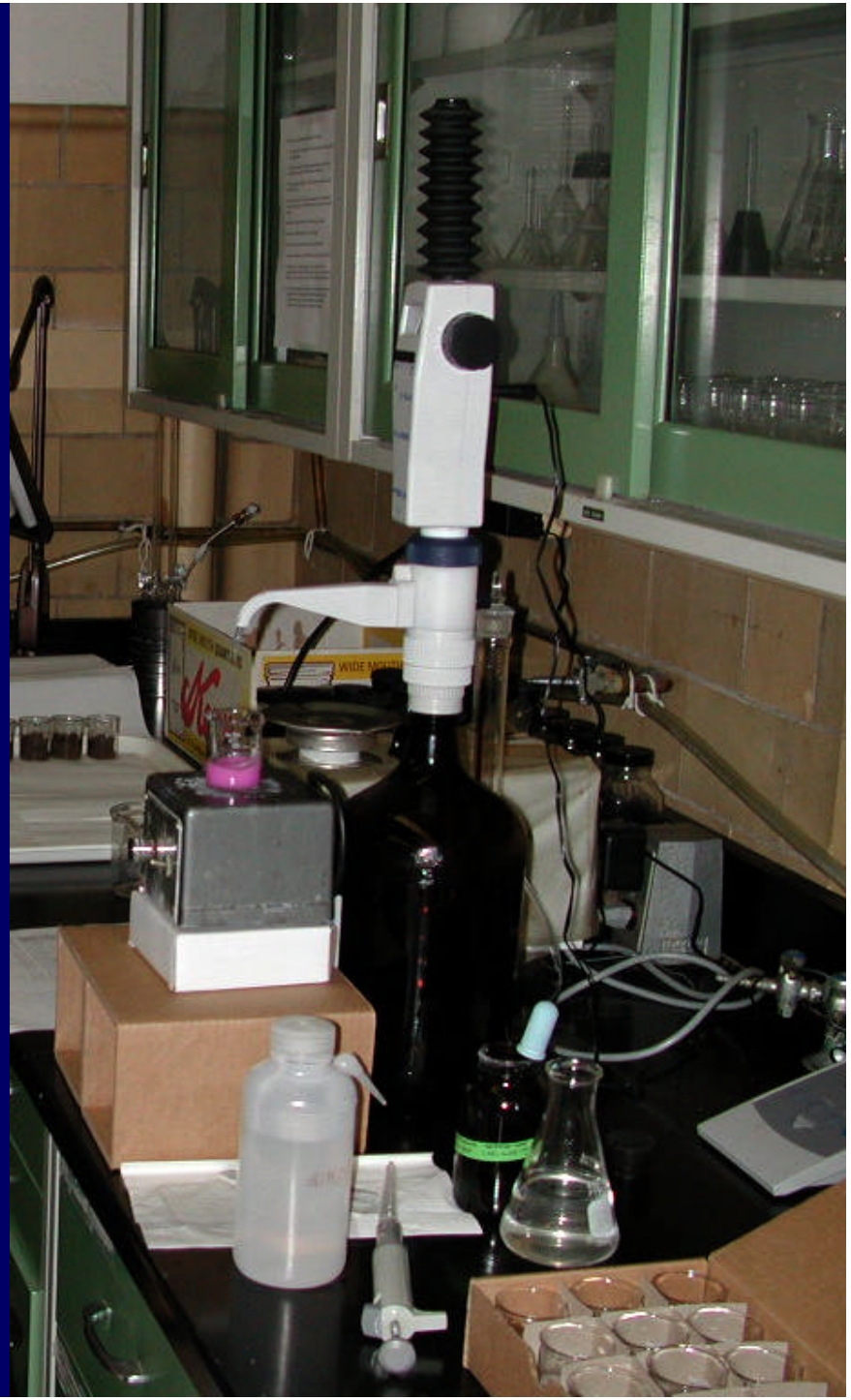
Quantifying the kinetic characteristics of soil organic matter decomposition in grasslands and in wooded landscape elements using long-term soil incubations under controlled conditions.

Methods - Long Term Soil Incubation

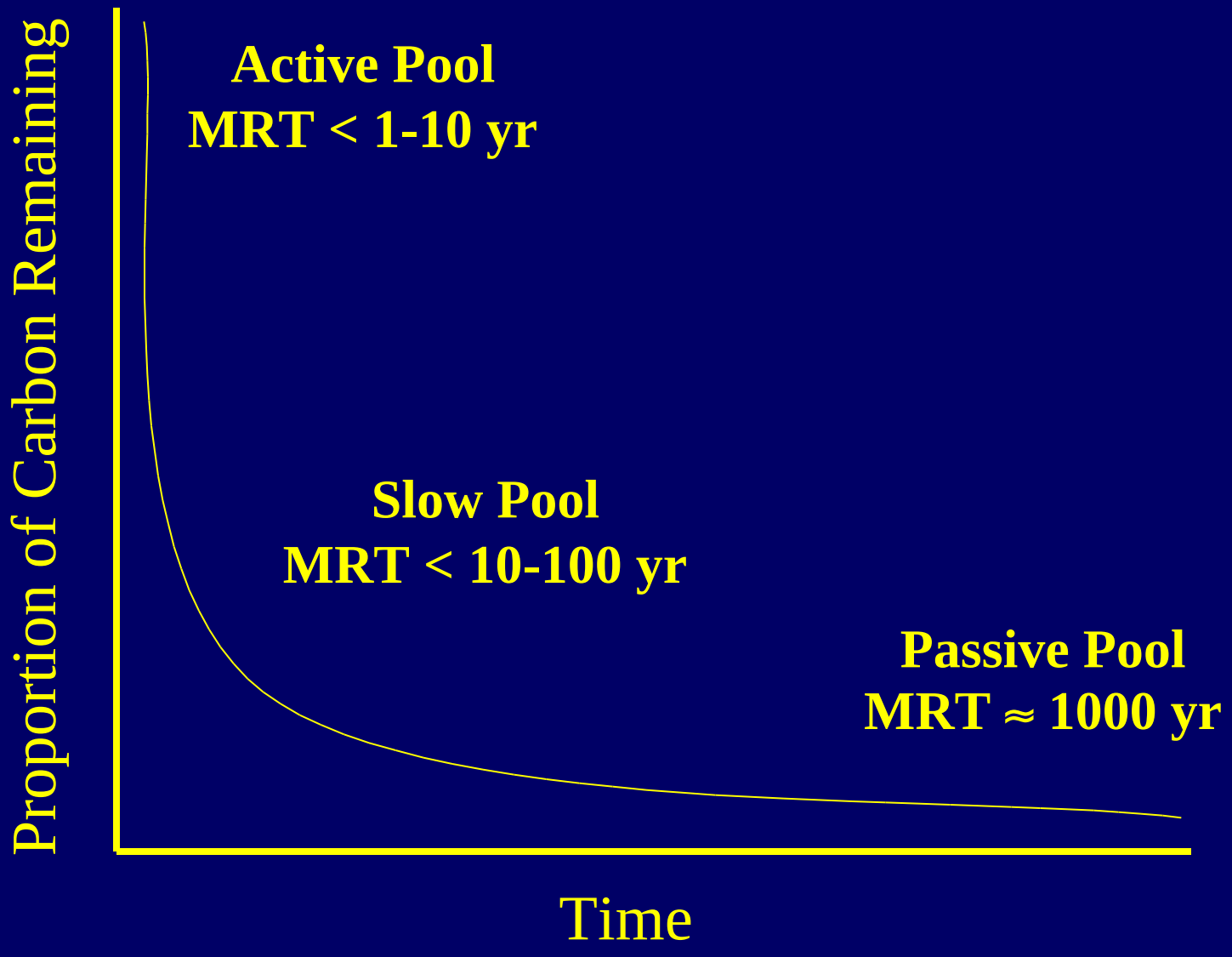
- Soils (0-10 cm) collected from Grassland, Cluster, Grove, and Drainage landscape elements
- Soils passed thru 4 mm sieve and moistened to 80% field capacity; aliquot measured for bulk organic C.
- 30 g soil incubated in 1-L vessels at 20, 25, & 30^{o}C.

Methods - Long Term Soil Incubation

- CO_2 trapped in NaOH and quantified by titration periodically.
- Pool sizes and MRTs for organic C pools determined by compartmental analyses of CO_2 kinetics.



Conceptual Model of Soil Organic Carbon



$$C_t = C_a e^{-k_a t} + C_s e^{-k_s t}$$

C_t = total organic C at time t

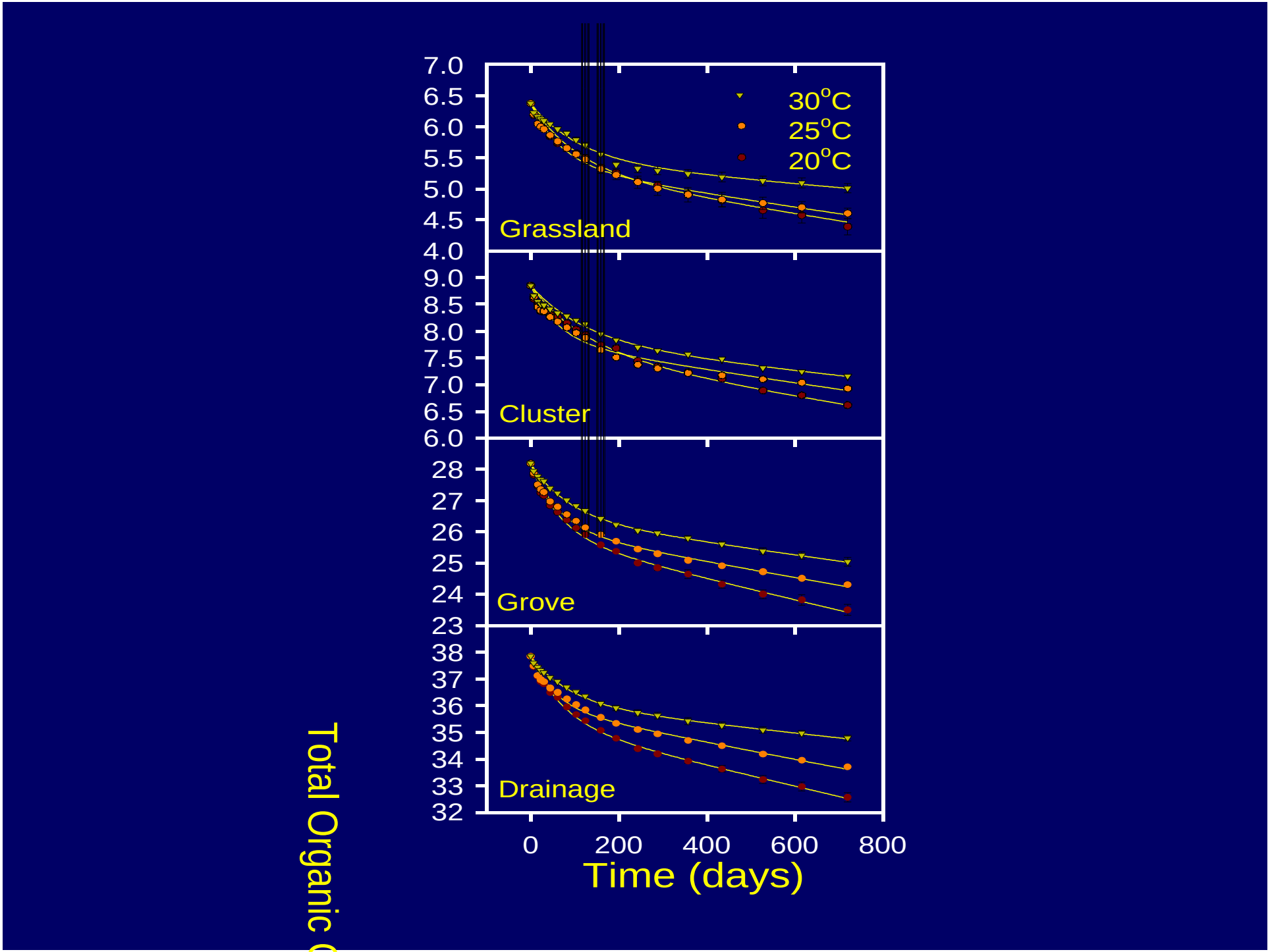
C_a = carbon content of the active pool

k_a = rate constant for the active pool

C_s = carbon content of the slow pool

k_s = rate constant for the slow pool

e = the base of the natural logarithm


Total Organic Carb
7.0
6.5
6.0
5.5
5.0
4.5
4.0
30°C
25°C
20°C
Grassland
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Cluster
28
27
26
25
24
23
Grove
38
37
36
35
34
33
32
Drainage
0
200
400
600
800
Time (days)

	Active Pool		Slow Pool		
Landscape	Mean Residence Time (days)	C_a (gC/kg soil)	Mean Residence Time (yrs)	C_s (gC/kg soil)	Total Organic C (gC/kg soil)
Grassland					
30°C	103.9	1.02	10.87	5.35	6.38
25°C	70.5	0.98	12.06	5.40	6.38
20°C	109.8	0.90	22.43	5.47	6.37
Cluster					
30°C	123.3	1.16	13.08	7.70	8.85
25°C	63.6	1.04	15.77	7.81	8.85
20°C	123.1	1.01	21.65	7.84	8.85
Grove					
30°C	63.8	2.25	20.00	25.93	28.18
25°C	63.9	2.09	25.00	26.10	28.18
20°C	86.5	1.70	33.33	26.49	28.19
Drainage					
30°C	72.7	2.45	25.00	35.40	37.85
25°C	56.5	1.90	33.33	35.95	37.85
20°C	90.1	1.77	50.00	36.08	37.85

Conclusions - Long Term Incubations

- **Land uses can alter ecosystem carbon storage by changing species composition and the quantity and quality of organic matter inputs.**
- **Larger SOC in woodlands sustained respiration rates up to 180% greater than grasslands.**
- **Despite greater respiration, MRTs of SOC were larger in woodlands than grasslands.**
- **Increased MRTs and increased slow/recalcitrant pool sizes probably result from inputs of lignified woody tissues that decompose slowly.**

Conclusions - Long Term Incubations

- **Kinetic analyses showed slow/recalcitrant pools up to 600% larger in woodlands than grasslands.**

- **Estimates of pool sizes and flux rates varied with incubation temperature, indicating microbial sensitivity to temperature.**

- **Grassland-to-woodland conversion during the past century has been geographically extensive in grassland ecosystems worldwide, suggesting that changes in SOC storage and dynamics documented here could have significance for the global carbon cycle.**